Analysis by Citizen Scientists of Doppler Radio Observations of the April Solar Eclipse

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Citizen Scientists

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- Other collaborators: Nathaniel Frissell, William Engelke, Gwyn Griffiths, Steve Cerwin

Observation Data Set

- 47 Ham Radio Receiver Stations:AB1XB Node 33, AB1XB Node 51, AB4EJ-Grape1, AC0G_MO, AC0G_ND, AD0RR, ADKSILO, K4BSE, K5TR, K9TRV RX888, KA7OEI, KB1HFT Node 36, KD6O-1, KD1LE node 43-1, KD1LE node 43-2, KD1LE node 43-3, KFS-NW, KFS-OMNI, KFS-SE, KFS-SW, KI7DLN-Grape1, KJ6MKI, KPH, KV0S_MO, N00000011, N2IC, N3AGE, N4TVC S44/N53, N4TVC, N4TVC S45/N58, N5BRG-Grape1, N5BRG-Grape-1-MAG1, N5TNL-rx888, N6GN, N8GA, Robs station, St George, N4RVE-TurnIsland, VA7DXX_1, WW0WWV0-W0DAS, W1XP, W1XP 2, W1XP NC, W2NAF, W7LUX, WI6P GRAPE1_DRF, WN1PBD
- Many heard only one frequency (10 MHz from WWV in Colorado)
- Others heard 9 frequencies from WWV, and also 3 from CHU in Canada
- Total number of observations was 206, but only 140 were useful, with non-zero values for the eclipse Doppler shifts.

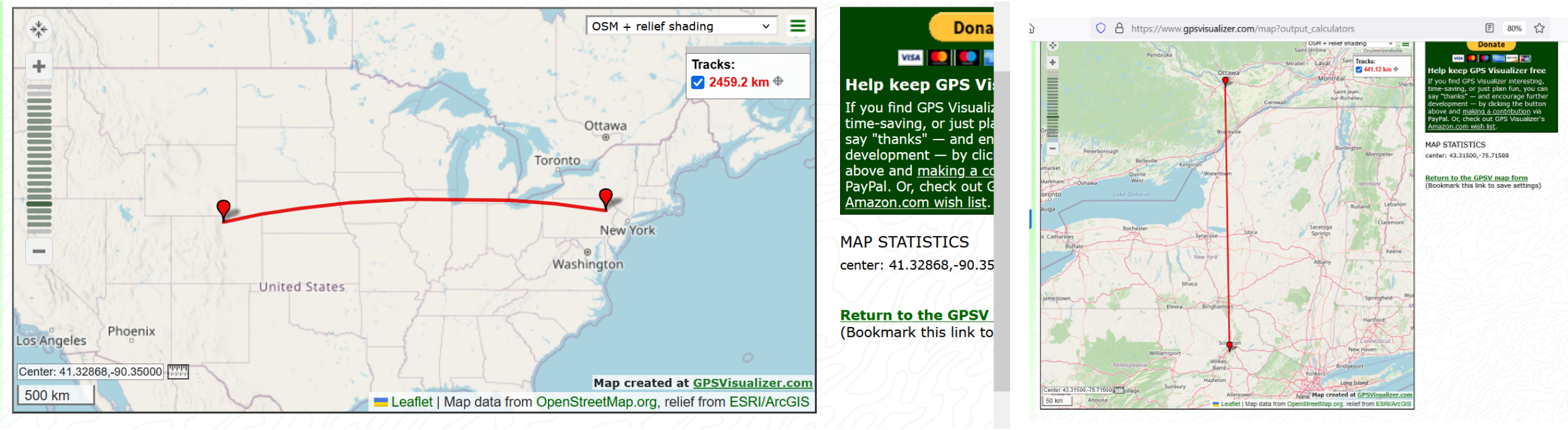
Data collected for each observation (28)

- Demographic: Callsign, Receiver Latitude, Receiver Longitude, Receiver Grid Square, Receiver town and state, Person's name, Person's home grid square, Is the eclipse receiver at the person's home grid square?
- Radio Details: Channel, Frequency (MHz), Transmitter (WWV or CHU, indicated by the frequency), Distance from transmitter to receiver (km), Direction from transmitter toward receiver, Initial bearing, Midpath latitude, Midpath longitude, Midpath town and state, Did the path go through any totality?
- Eclipse information: Mid-eclipse local time (Daylight), Time zone, Mid-eclipse UTC, Midpath location's maximum obscuration.
- Radio observations (PSWS green plots): judgement of symmetry of ingress/ egress, number of modes, maximum Doppler shift negative (ingress, Hz), maximum Doppler shift positive (egress), comments.

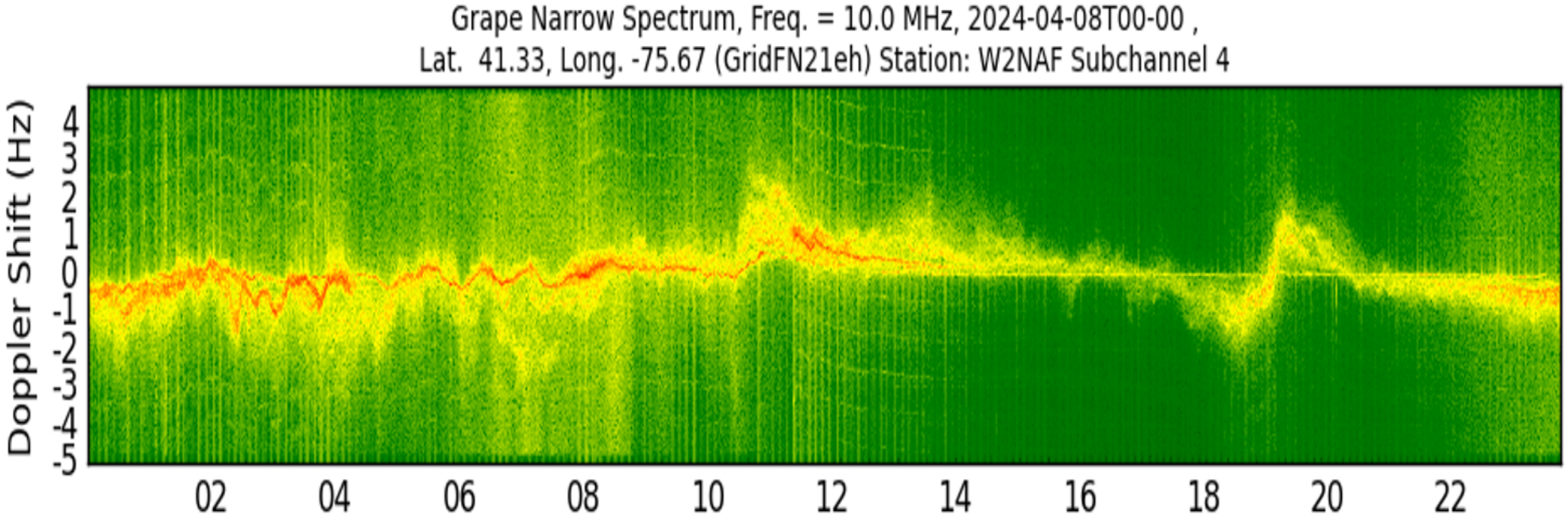
Sources of Information

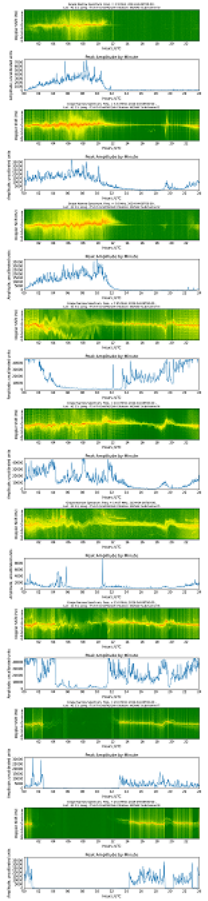
- https://www.levinecentral.com/ham/grid_square.php

- https://www.gpsvisualizer.com/calculators

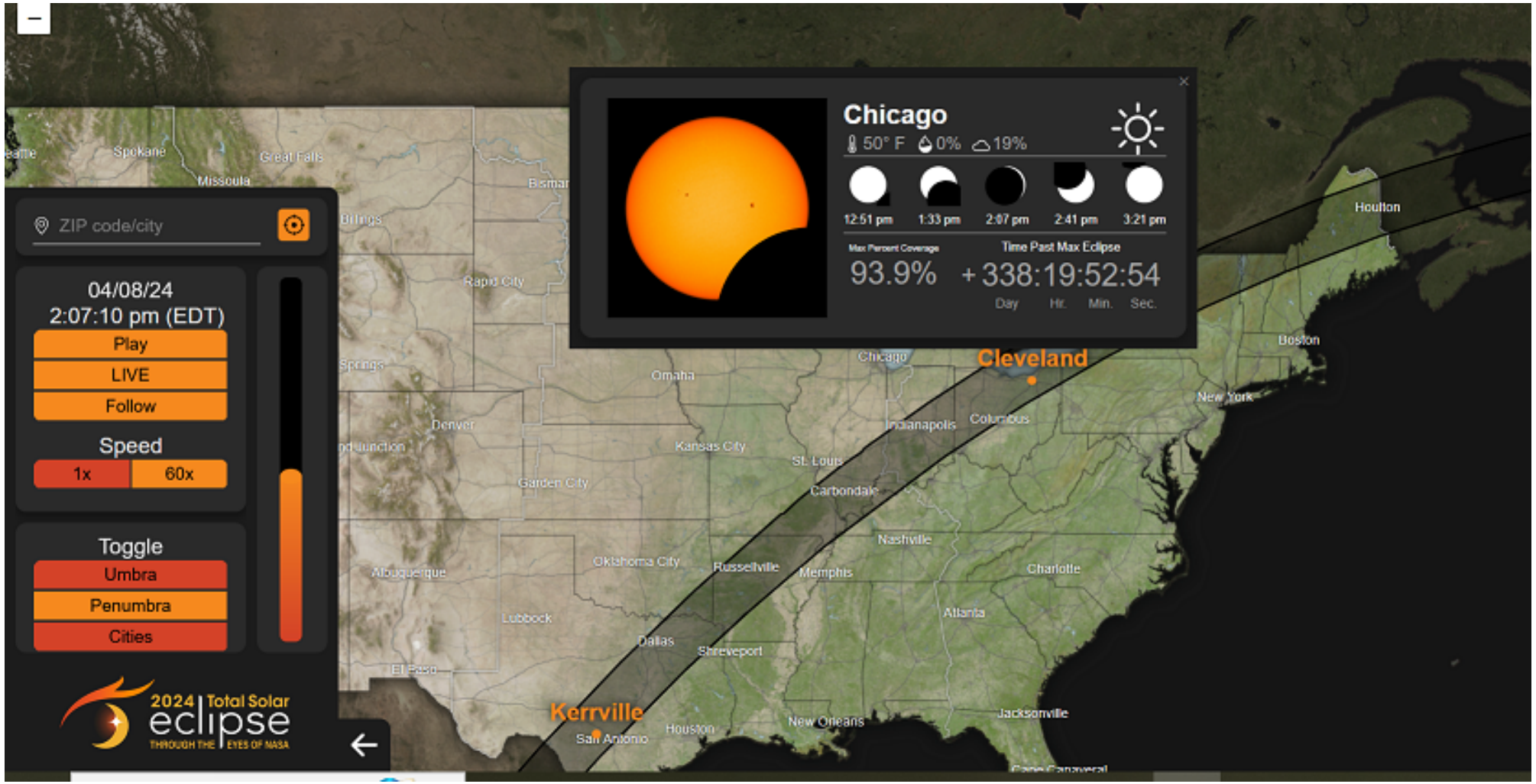


PSWS observations
https://PSWSnetwork.caps.ua.edu





Eclipse Data
https://eclipse-explorer.smce.nasa.gov/



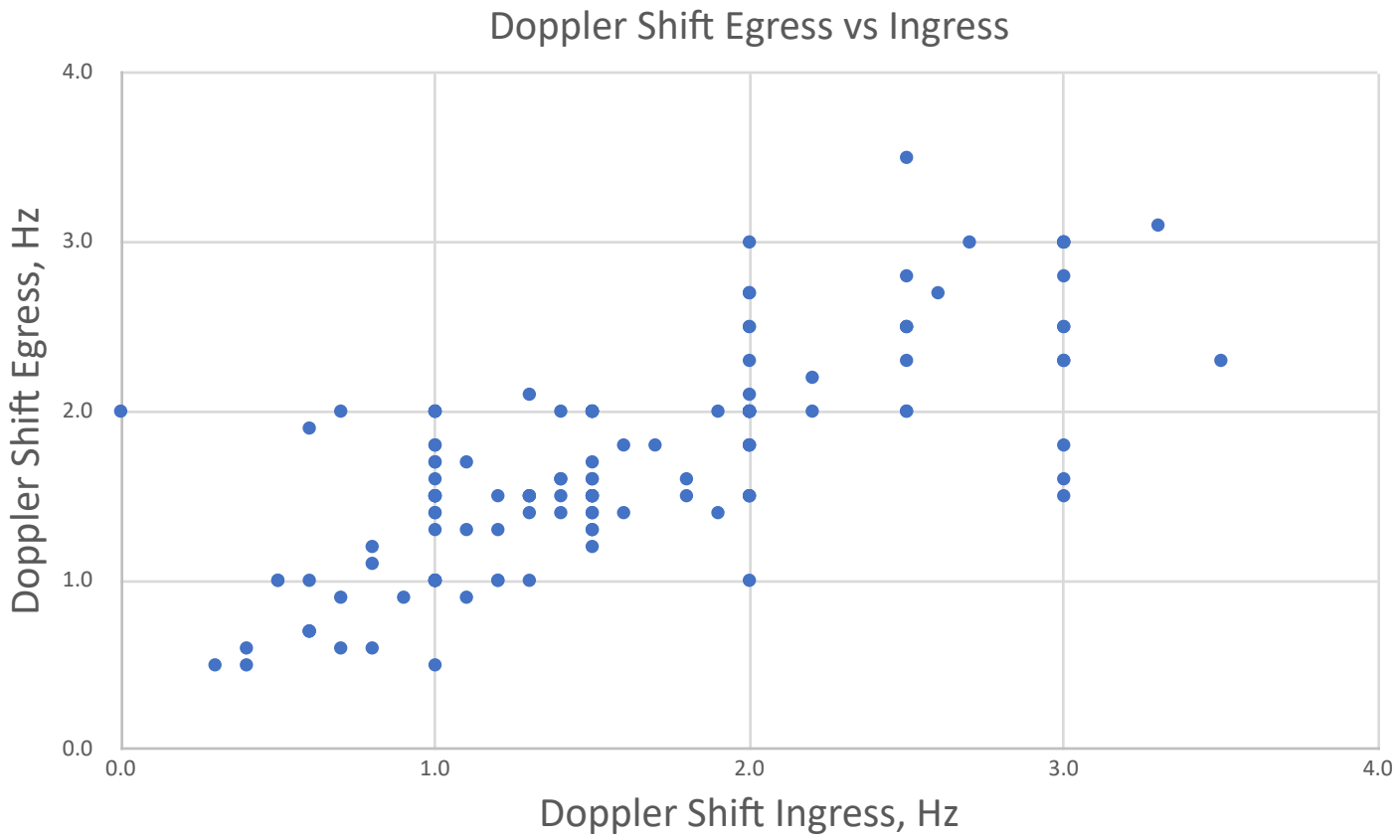
Question: Are any of the outputs correlated with the inputs?

- OUTPUTS:
- Eclipse Doppler shift at ingress
- Eclipse Doppler shift at egress
- Number of modes
- Symmetry of ingress/egress

- INPUTS:
- Radio frequency, Distance from transmitter, Time of day, Midpoint location, depth of obscuration, Direction

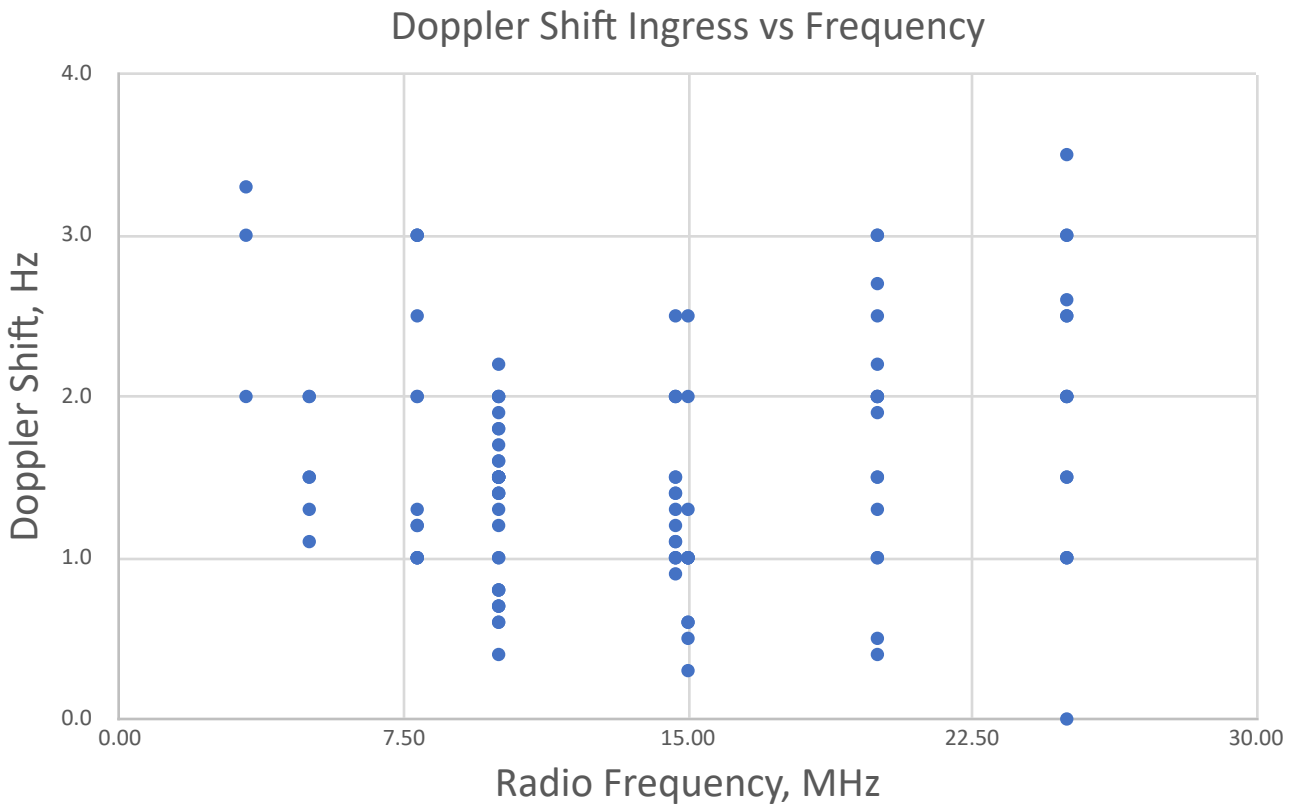
Expected correlation, Doppler Shift

- For all radio frequencies, ingress and egress are similar



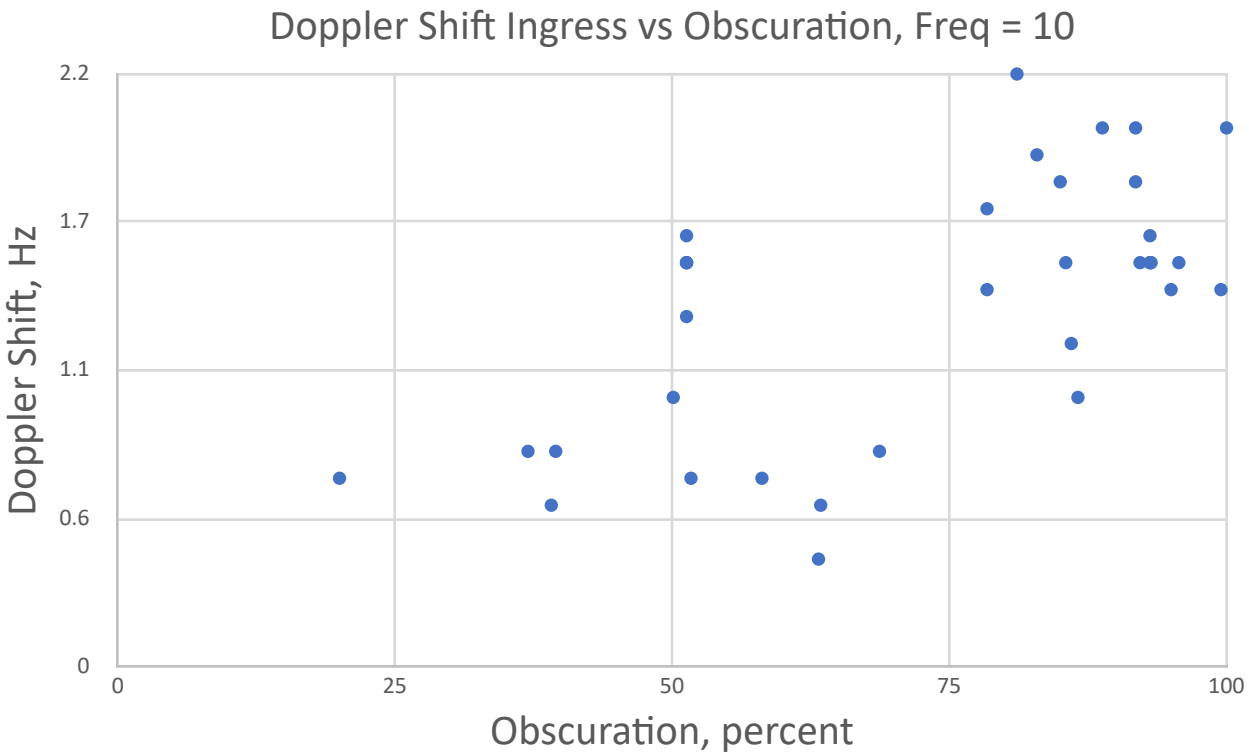
Doppler Shift at Ingress vs Radio Frequency

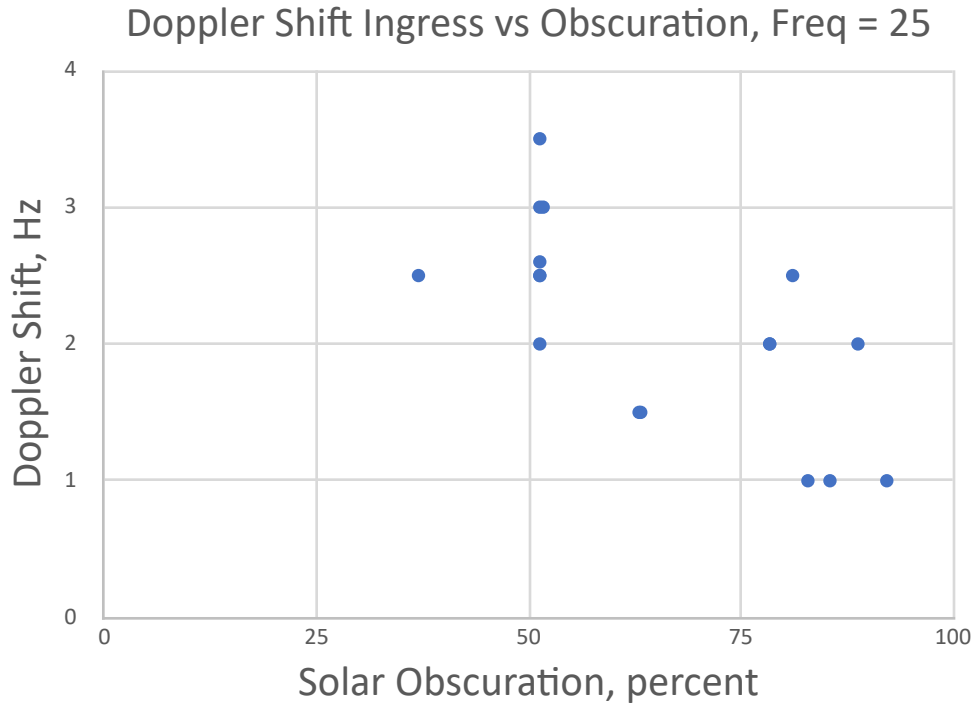
- Peaks at high and low frequencies



Doppler Shift Ingress vs Solar Obscuration

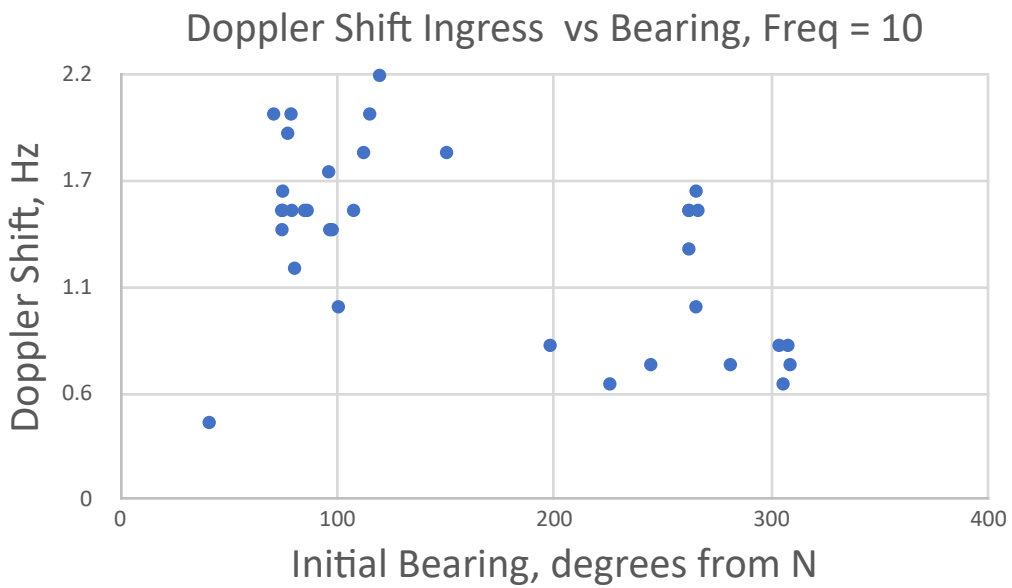
- Doppler shift increases with depth of eclipse, at 10 MHz
- But decreases with solar obscuration at 25 MHz

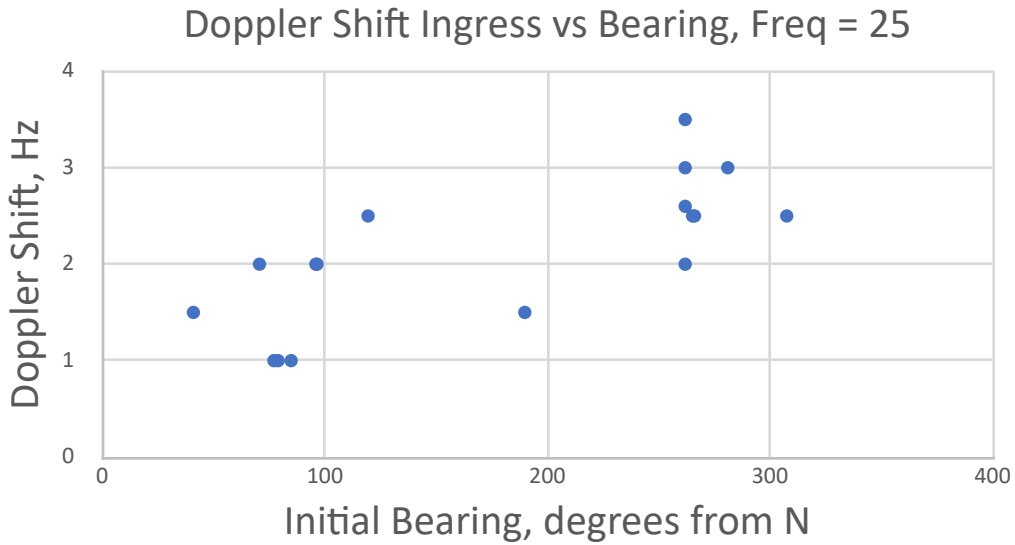




Doppler Shift vs Initial Bearing

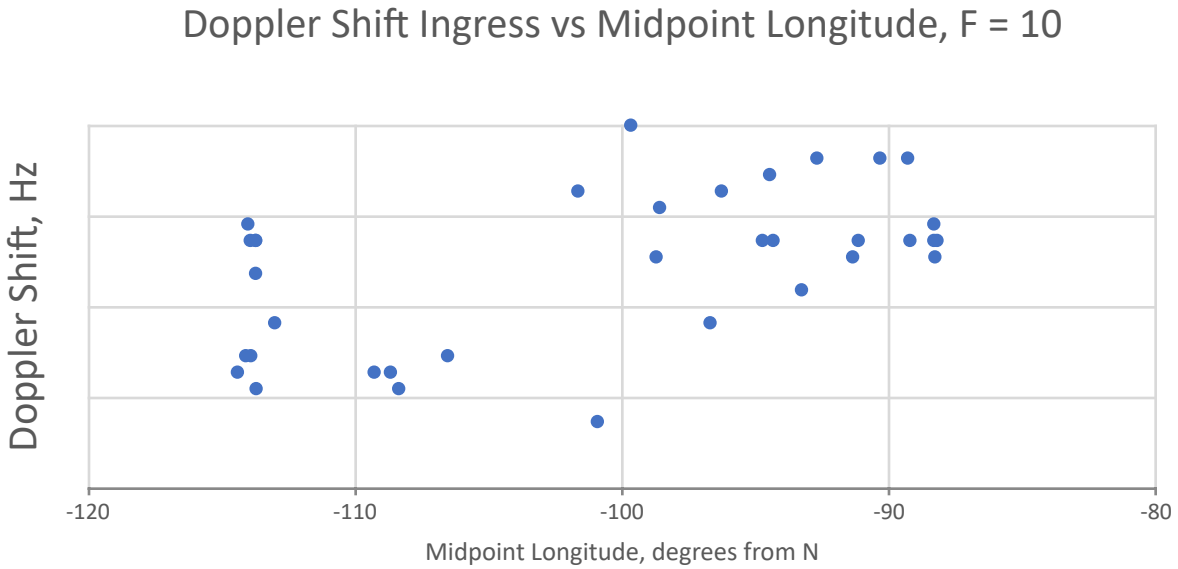
- Doppler shift decreases with initial bearing at 10 MHz
- Doppler shift increases with initial bearing (West coast) at 25 MHz

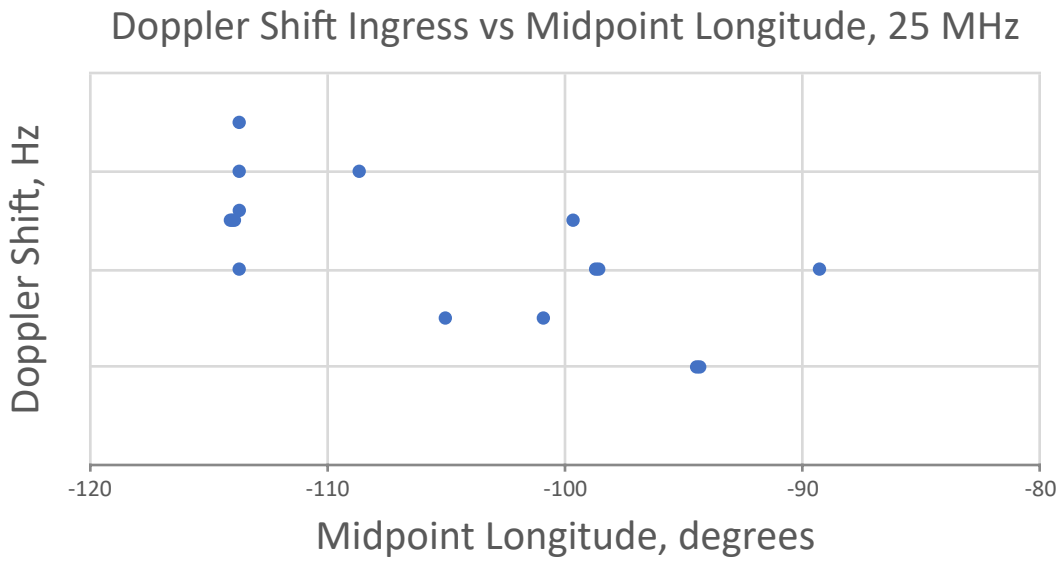




Doppler Shift Ingress vs Midpoint Longitude, a temperature effect on radio frequency?

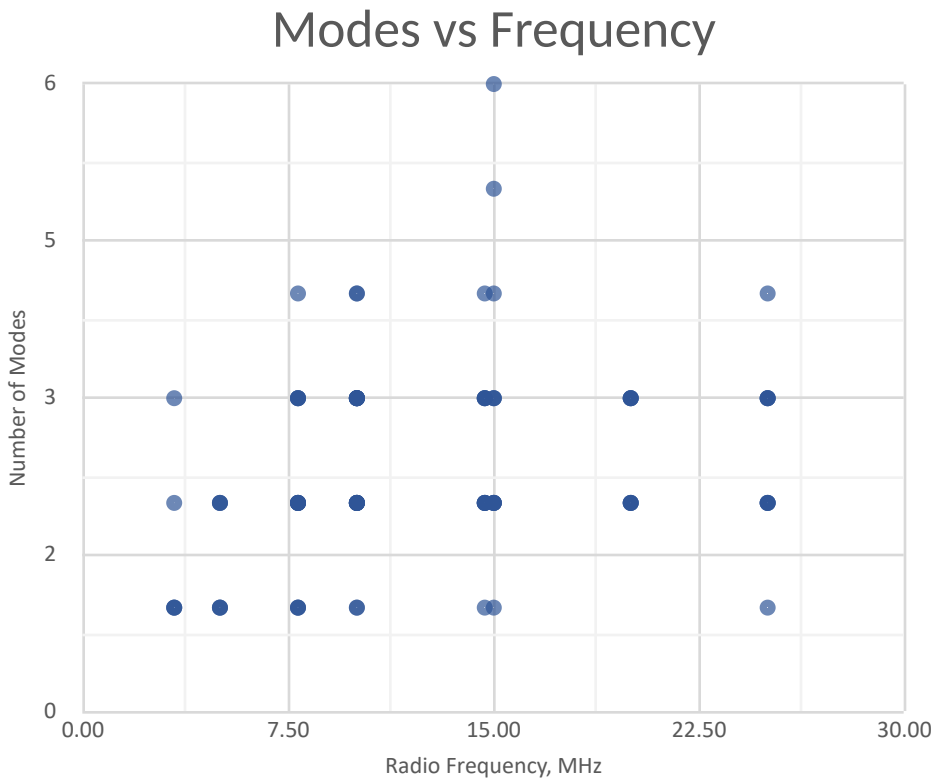
- Doppler shift increases at 10 MHz
- Doppler shift decreases at 25 MHz

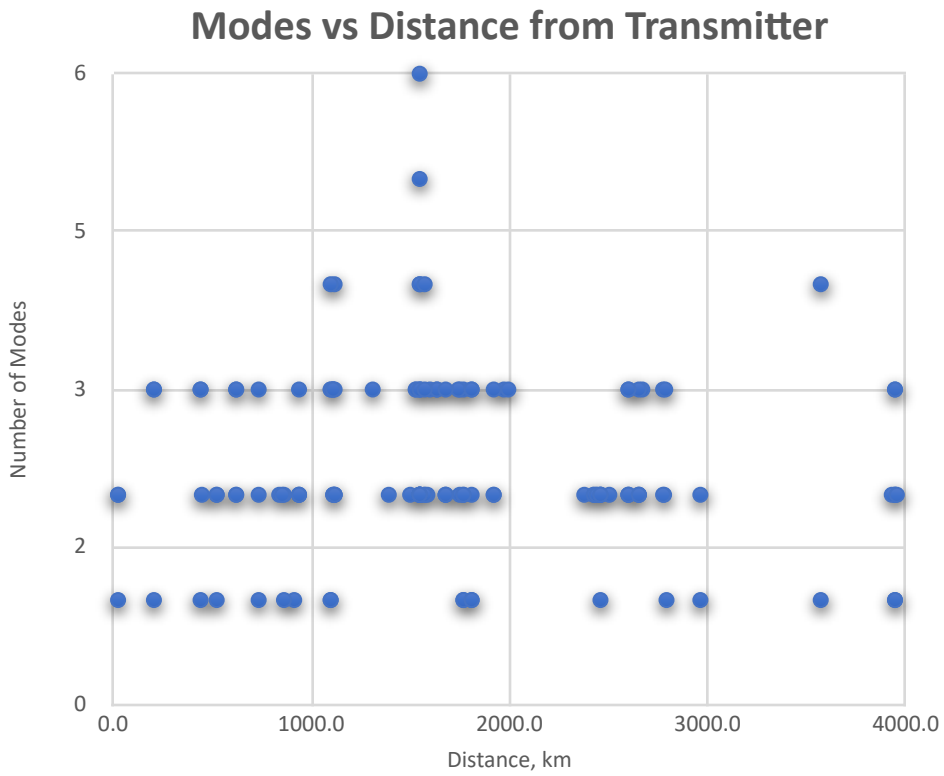




Number of Modes

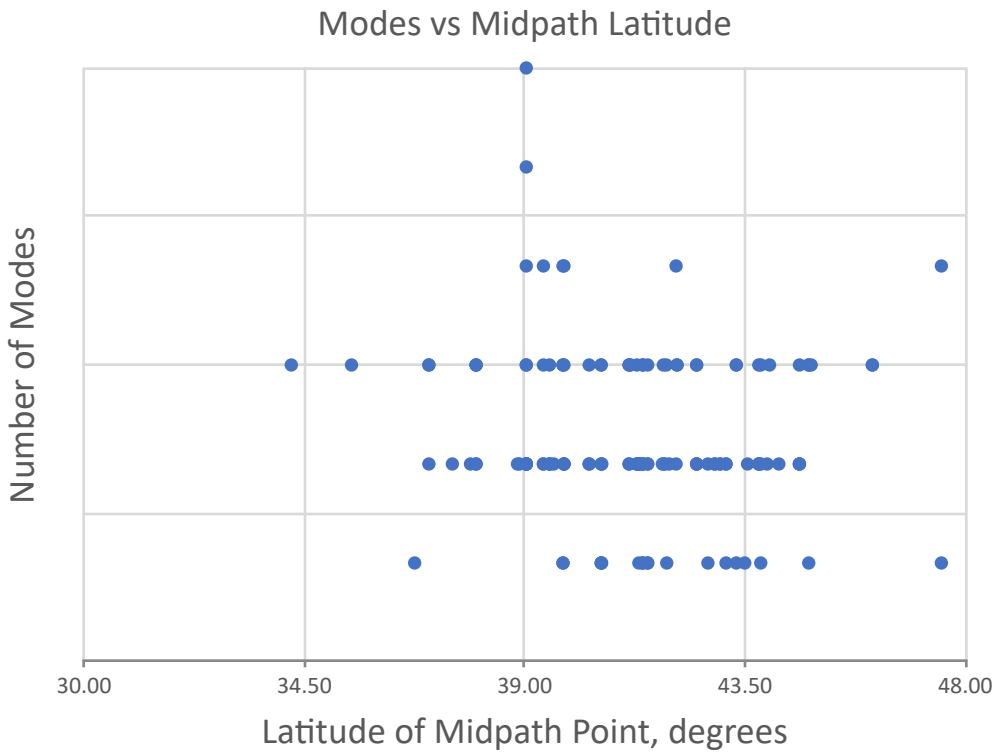
- The number of modes peaks at 15 MHz
- The number of modes peaks at 1500 km

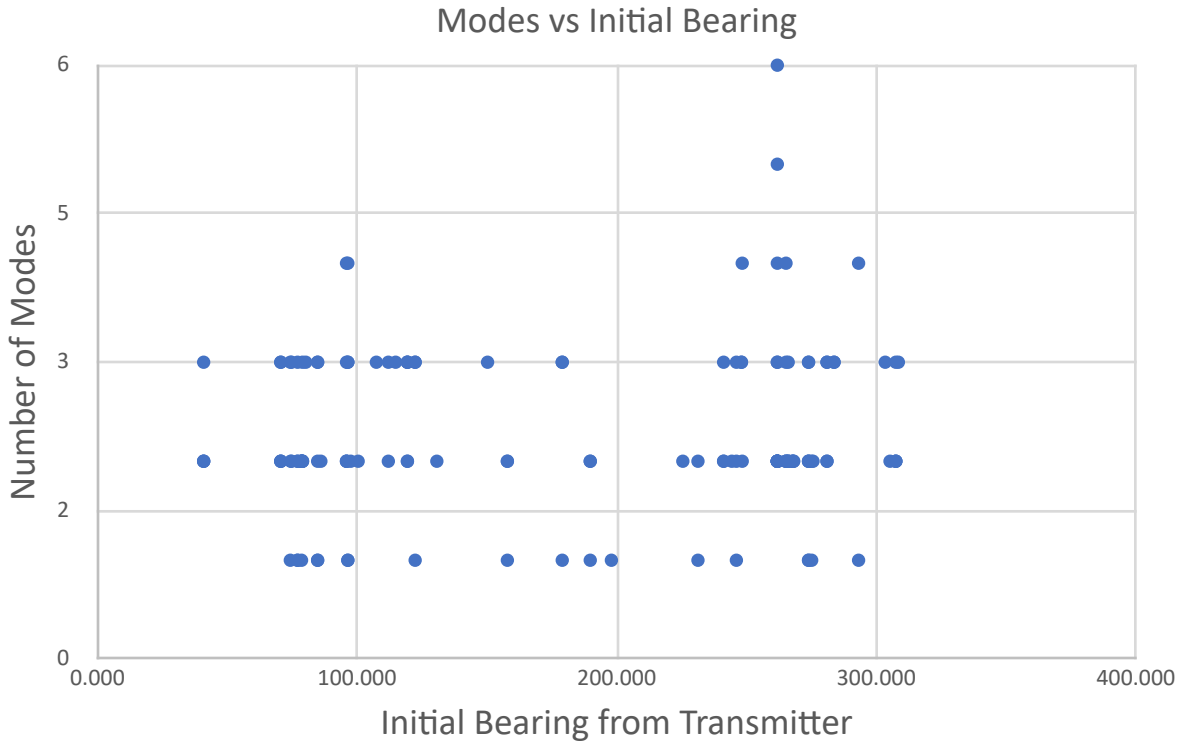




Number of Modes

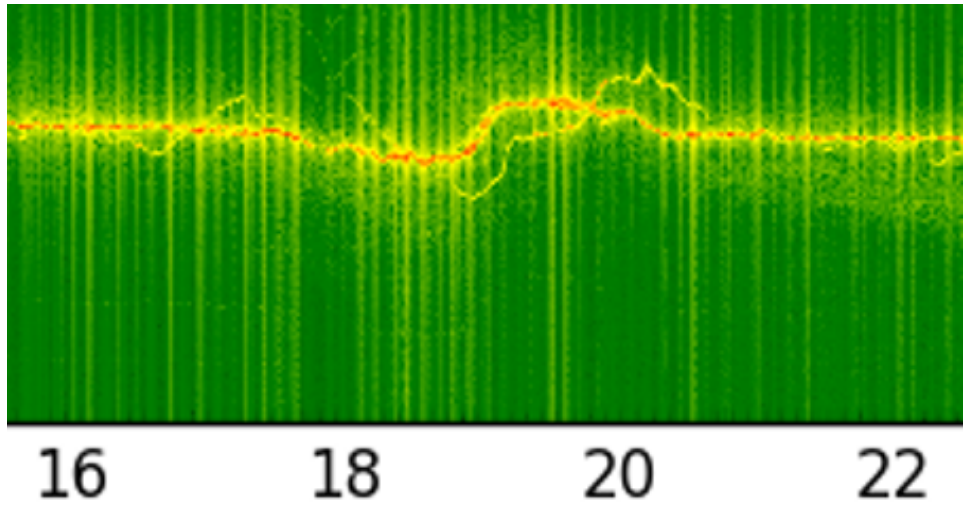
- Number of modes peaks slightly at 39 degrees latitude.
- Number of modes peaks at 100 (east) and 260 degrees (west).





More to come

- Dawn oscillations
- Analysis of the Annular Solar Eclipse, October 14, 2023
- Comparison with ray tracing models
- Comparison with ionosonde observations
- Puzzling cases



Thank you for your attention

- Thank you for paying your taxes